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ADVANTAGES AND LIMITS OF THE COUPLING SYSTEMS FOR ATTACHING ACCESSORIES ON CONSTRUCTION EQUIPMENTS

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ABSTRACT: The purpose of this article is to briefly describe the main systems of quick coupling for attaching accessories used by construction equipment and their operating principles. We aim to emphasize the advantages and disadvantages of using these systems and finally we will try to find a new system solution that is completely different from current mechanisms. The reason for making this proposal is the desire to provide users of such kind of equipment a new and modern quick coupling system, which provide all the advantages and benefits of conventional systems and eliminate their drawbacks.

Keywords: coupling systems, construction equipment, new design

1. OVERVIEW CONCERNING QUICK COUPLING SYSTEMS

In construction field, a very important place is occupied by construction machinery. These machines are complex systems that are used to manipulate various materials, especially on construction sites, for demolition, or the extraction of stone from quarries for extraction and handling of certain varieties of gravel.

The most common machine in the construction sites it is the excavator. This equipment is used in most of the works of construction. In order to be efficiently used, there were designed a wide range of accessories such as excavating buckets, levelling buckets, grabs, rippers, hydraulic hammers, shears, pulverisers, hydraulic drills, etc., illustrated in Figure 1.

Attaching and fixing these accessories at the excavator's arm can be done in different ways. For this purpose, there were conceived and designed various mechanisms, which give firmness and operating safety to the accessory fitted to excavator.

Because each producer tried to customize their own attaching systems, at this moment there are various such systems on the

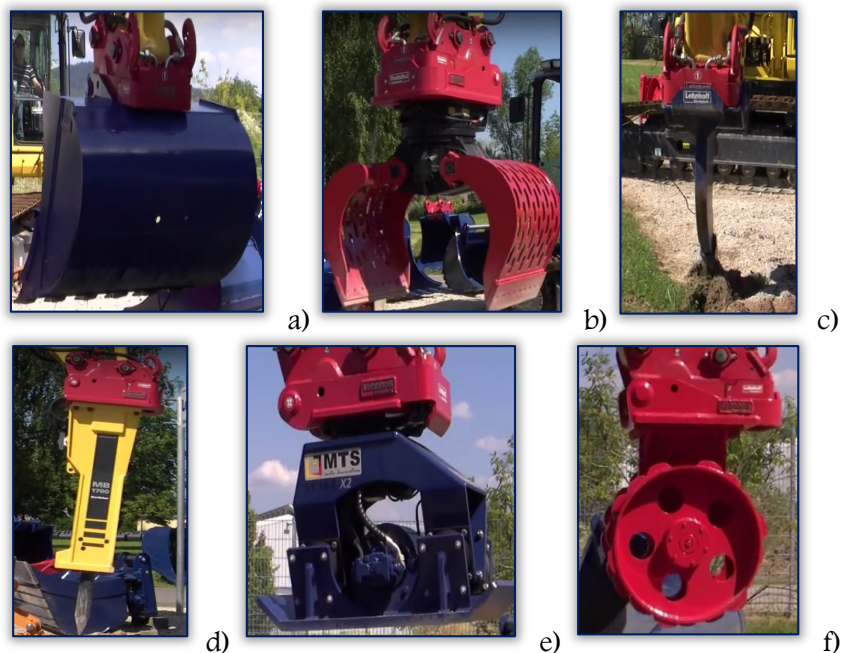


Figure 1. Range of accessories of the excavator
a) Excavating bucket; b) Gripper; c) Ripper; d) Hammer; e) Vibrating plate; f) Soil compactor

market. Fixing systems are subjected to very high stresses and work in different media more or less abrasive. Because of this, in joints and between parts in contact, the clearance grows in time because of the wear, which can lead to irreparable damage in extreme cases.

In the following there are briefly presented the most common quick couplings.

2. THE CURRENT STATE OF QUICK COUPLING SYSTEMS FOR ATTACHING ACCESSORIES AT THE EXCAVATOR’S ARM

Currently, fixing the accessories on excavator's arm can be done by two different ways:

- ~ Direct fit using bolts;
- ~ Quick coupling systems.

Direct attaching system using the bolts

In this case the attachment has two parallel ears with two bores each (Figure 2). Paired bores have parallel axes to allow the passage of fixing bolts. The rod and the arm, present also bores, destined for mounting the connecting bolts.

The arm and the rod will be inserted between the two ears of the attachment and when the bores of the rod and of the arm will be on the same axis with the two pairs of bores of accessory’s ears, then will be successively mounted the mounting bolts.



Figure 2. Classic attaching system using the bolts

This mounting solution is used especially if the machine works

with the same accessory more than 80% of the time. The solution using fixing bolts creates a very strong assembly between machine and accessory – this is the main advantage of this technical solution.

The main disadvantage of this coupling system with bolts, is that when is necessary to replace an accessory, this can only be done by dismantling and mounting the bolts. These operations require time and a heavy workload especially for the large machines. In this case the bolts are large and they are very heavy. Their dismantling and mounting need a long time and heavy workload under conditions of construction site and bad weather.

Quick coupling system

Another attaching system (see Figure 3 and Figure 4) is the quick coupling system and one will be presented in details both their advantages and disadvantages. In general, fitting accessories on the excavator's arm, using a quick coupling system, is less firm, but has the advantage that gives operators the opportunity to quickly and effortlessly replace the accessories required in the production process. The quick couplings can have various shapes and operation modes.

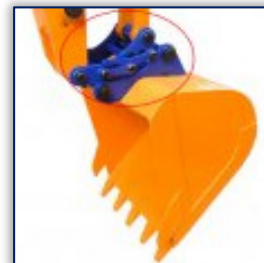


Figure 3. Quick coupling system, designed by the TEFRA Company [2]

Another indisputable advantage of these technical solutions, attaching with quick coupling systems, is that it allows using the same accessory, which was originally fixed with bolts directly without any further modification; in fact, these coupling systems are interposed between the excavator arm and accessory. These quick couplings have also some disadvantages like:

- ~ Quick couplings are composed of a large number of moving parts that wear out over time, causing the appearance of the games that grow over time. Increasing these games beyond a certain point, leads to major deformities, and in extreme cases even break certain items.
- ~ the size range of these quick couplings is usually very big, and depending obviously by the size of equipment; thus, for example, the manufacturer Verachttert provides users, nine different dimensions of coupling systems for excavators working in the range (10 – 1000) kN.



Figure 4. Detail of the mechanical coupling system from Figure 2 [2]

In the most cases, quick coupling systems have two hooks, which are fixed on accessory's bolts. One of the hooks is fixed and the other one is mobile. The mobile hook's position is adjusted mechanically or hydraulically and it is determined by the distance between bolts on which the quick coupling system will be fixed.

Depending on the mode of operation of the movable hook, one has two different solutions:

- a.) Mechanically - operated quick couplings;
- b.) Hydraulically - operated quick couplings.

The mechanically-operated quick couplings are then divided in 3 categories:

- a.1) Screw-operated mechanical couplings (Figure 5);
- a.2) Spring-operated mechanical couplings (Figure 6);
- a.3) Articulated mechanical coupling (Figure 7).

The hydraulically-operated quick couplings also are then divided in 3 categories depending on mobile block element:

- b.1) Hydraulically - operated quick couplings with mobile hook (Figure 8);
- b.2) Hydraulically - operated quick couplings with mobile locking fork (Figure 9, Figure 10);
- b.3) Hydraulically - operated quick couplings with mobile locking edge (Figure 11).

a.) Mechanically - operated quick couplings

In case of screw-operated mechanical quick couplings (case a.1, Figure 5), fitting accessories are made as follows: the accessory (bucket) which was initially fixed with bolts directly on the boom is to be removed. After removing loose bolts, these will be installed in the bores of the bucket. Instead of the accessory (bucket), on the excavator's arm will be mounted quick coupling system. When attaching the accessory, the fixed hook of the coupling system is fastened to the accessory's bolts and the moving hook will be adjusted with the screw until it gets close to the second bolt of accessory.

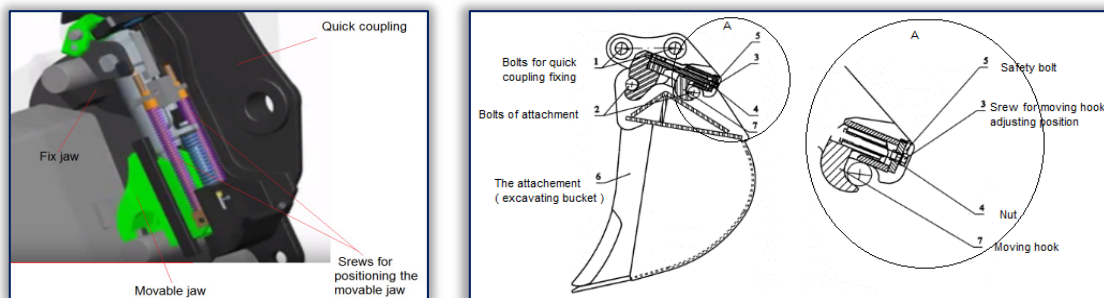


Figure 5. Mechanical quick coupling screw operated system, designed by the GeithCompany [3]

Quick couplings systems spring - operated (case a.2, Figure 6) work on the same principle as the screw-operated ones. The difference is that the screw is replaced by a spring, which will permanently press the moving hook on the second bolt of accessory. Attaching by the usage of this coupling system is not as strong as the one with screws system.

For safe operation, after mounting accessory, a safety bolt will be installed behind the moving hook in order to block movement of this moving hook and accessory's accidentally detachment. In order to be able to attach the accessory to the coupling system, the spring that pushes the movable hook has to be tensioned. This is done using a lever. After the spring has been compressed so as to allow the moving hook to pass besides the bolt, the lever is removed and the spring will push the moving hook and put it in permanent contact with the bolt. In the end the safety bolt will be installed behind the moving hook

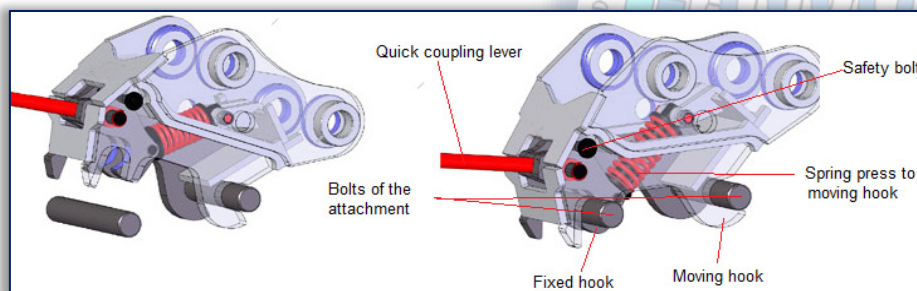


Figure 6. Spring-operated mechanical quick coupling system designed by Volvo and Geith [4]

Quick coupling with joint systems (case a.3, Figure 7) is based on the fact that the geometry of the end of the excavator's arm linkage is modified with cylinder rod movement through which it is

operated. Thus, when the cylinder's stem is withdrawn the two bolts from end joints are close enough to allow the passing into the brackets of the bucket. By pushing out the stem of cylinder's rod, the two joint bolts will be warded off and coupled on the bucket's hooks. In this position, the joint will be locked using two locking screws.

b.) Hydraulically operated quick couplings

Quick couplings hydraulically operated, a hydraulic cylinder makes work just as mechanical quick couplings but the movement of the moving hook.

EVERDIGM Korean manufacturer provides users a high-performance and reliable coupling system (case b.1) which have a special locking hook which prevents detachment and stop fall of that accessory when removal him from the excavator's arm is needed. This auto-locking hook is presented with number 5. Figure 8 shows the coupling EVERDIGM in two positions: open and closed.

The idea of preventing hair accessory when the operator wants decoupling them from the excavator's arm comes as an advantage of this system but in same time the entire mechanism becomes more complicated because for moving this locking hook we should have of another dual action hydraulic cylinder, hydraulic valve, additional button etc. Obviously all these joints are subject to wear.

The Verachttert product represents one another model of quick coupling hydraulically operated (case b.2). In this case the excavating bucket has two hooks and two locking tabs in opposite side.

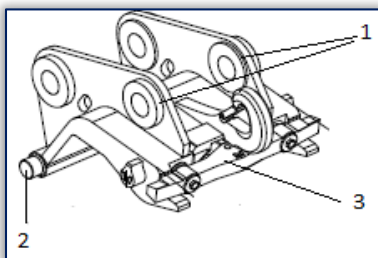


Figure 9. The hydraulically operated quick coupling components with mobile fork Verachttert [7]:

- 1 – two pairs of holes with parallel axles for fixing at the arm of the excavator,
- 2 – two bolts fixing,
- 3 – hydraulically operated mobile locking fork



Figure 7. Articulated mechanical quick coupling designed by the company MB Spa [5]

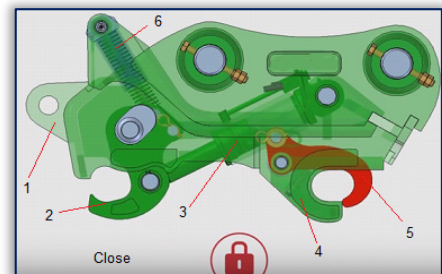
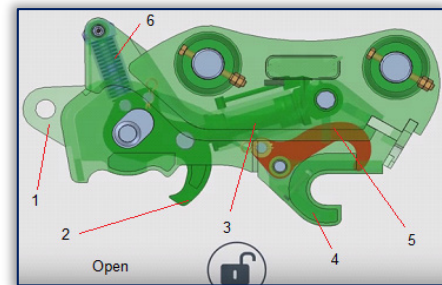


Figure 8. Hydraulically operated quick couplings system in the open and close positions [6]

- 1 - Lifting hook;
- 2 - Moving hook;
- 3 - Main hydraulic cylinder;
- 4 - Fixed hook;
- 5 - Auto locking safety hook;
- 6 - Auto locking safety spring

In Figure 9 is presented the VERACHTERT coupling system components, and in Figure 10 is presented the quick coupling system in different positions.

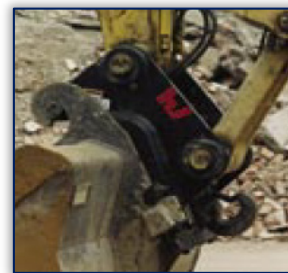
In order to attaching accessory, the operator will move quick coupling system near to accessory (Figure 10 a), until fixed bolts (2) will be fixed on the two hooks of the accessory (Figure 10 b). By opening the rotation hydraulic cylinder's the excavator arm, operator will move the quick coupling in proper position for fixing locking fork in the locking tabs of accessory (Figure 10 c). By moving the locking fork, the attaching of those two components (quick coupling and accessory) will be done.



a)



b)



c)

Figure 10. Different positions of the hydraulically operated quick coupling with mobile fork from Verachttert [7]

The Volvo manufacturer provides to users three quick coupling systems of different sizes depending on the size of equipment on that will be installed (case b.3). These couplings have the same operating mode and are numbered S1, S2 and S3.

Figure 11 presents the S2-type hydraulic quick coupling system of Volvo Company. In this case, the quick coupling mounted on the excavator's arm and the complementary part of the accessory, have a more complicated construction. The quick coupling has two hooks which sit on a bolts mounted on the accessory.

A hydraulically operated lock edge is moves until it latches a hook mounted on the accessory.

During working time, the attachment tends to move sideways. This kind of attachment moving will be locked using two screws screwed into two brackets strong welded on attachment plate. Once adjusted the position of the two screws, they are locked using nuts.

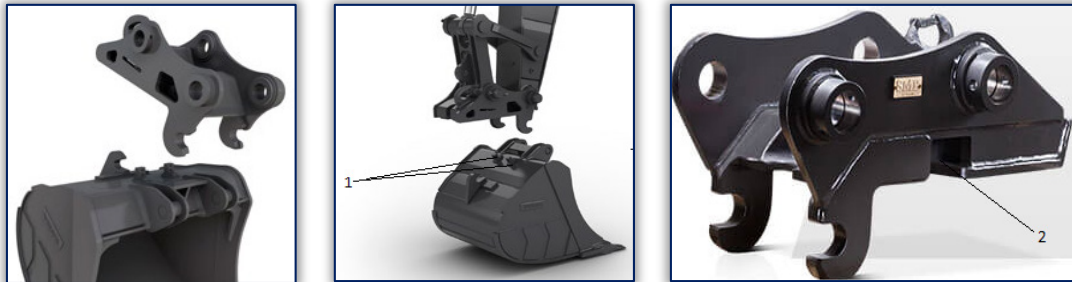


Figure 11. Hydraulic quick coupling S2 - designed by Volvo Company [8]

1 – two screw for locking sideways moving; 2 – sideways place where the screws will be press for locking sideways moving

Fixing accessories with quick couplings have the great disadvantage that the mounting is made with certain clearance between the parts in contact. These clearances get bigger over time due to wear; in some cases leading to irreversible damage to the coupling and finally to the breakage of coupling.

3. CONCLUSIONS AND PERSPECTIVES

These coupling systems are subject to great efforts during use. To limit the effects of these forces on coupling systems, each producer tried to create their own quick coupling's model, which is more resistant, having manufacturing costs as low as possible.

Because of this in the market, we have today a huge range of quick coupling systems each with advantages and disadvantages.

Advantages of quick coupling systems are:

- ~ firm attaching - provided by direct fit system;
- ~ easy and fast replacement of accessories provided by quick coupling system;
- ~ for moving the quick coupling mechanism will be used existing hydraulic fluid provided from machine's hydraulic system so no need to another system.

Disadvantages of quick coupling systems are:

- ~ large number of moving parts that wear out over time, causing the appearance of the games that grow over time;
- ~ space clearance between elements being in contact
- ~ another big disadvantage comes from the fact that the market there are too many types of coupling systems from multiple vendors, making it impossible to interchange the accessories. It happens so that in the working site be two, three excavators or more the same size, but from different manufacturers that may use only his own accessories without the possibility of using other accessories because of their different quick coupling systems

As a result of careful analysis of current technical solutions, our intention is to develop a completely new quick coupling's system which will incorporate few major advantages as follows:

- ~ reducing the number of elements which is included in quick couplings mechanism;
- ~ Significant reduction of the dimensional range;
- ~ Unifying of quick coupling concept.

At the same time, this new system has to eliminate the few major disadvantages as follows:

- ~ The risk of cracking of used elements;
- ~ Avoid using a complicated mechanism and hydraulics which moving entire system;
- ~ Many types and models on the market;

~ The operator must live the cabin and act manually screws or levers that block quick coupling - when using mechanical couplings.

To highlight the benefits of using quick couplers and to eliminate the disadvantages of the author intends to develop and implement a new concept that ensures strongly fixing of those two elements, in a short time.

This concept will lead to achieving a new quick connect system that will ensure minimizing the number of motion parts of the quick coupling. This new mounting system will have a simple construction and its execution will require reduced materials consumption.

Machining operations required to obtain this new coupling system will be simpler than the processing needed to obtain current systems. This new system will be made with much lower cost than existing systems currently.

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